TRANSLATION FROM JAPANESE

(19) JAPANESE PATENT OFFICE (JP)
(12) Official Gazette for Unexamined Patent Applications (A)
(11) Japanese Unexamined Patent Application No. H5-292624
(43) Disclosure date: 5 November, 1993

(51) Int. Cl.^{5} Classification Internal Office FI Technical Display Location

Int. Cl.^{5}	Classification Symbols	Internal Office Registration Nos.
H02G 1/14		7028-5G
H0R 43/00	A	7161-5E

Request for Examination: Not yet submitted
Number of Claims: 3
(Total of 5 pages [in the original])

(21) Patent Application No.: H4-94253
(22) Filing Date: 14 April, 1992

(71) Applicant: 000005290
Furukawa Electric Co. Ltd.
Marunouchi 2-6-1,
Chiyoda-ku
Tokyo-to

(72) Inventor: H. Noda,
c/o Furukawa Electric Co. Ltd.
Marunouchi 2-6-1,
Chiyoda-ku
Tokyo-to

(72) Inventor: S. Sakuma
c/o Furukawa Electric Co. Ltd.
Marunouchi 2-6-1,

Chiyoda-ku
Tokyo-to

(72) Inventor: T. Matsumoto
c/o Furukawa Electric Co. Ltd.
Marunouchi 2-6-1,
Chiyoda-ku
Tokyo-to

(74) Agent: Patent Attorney,
S. Nagazawa (and one other)

(54) [Title of the invention] Extrusion mould joining method for cross-linked polyethylene insulated cables

(57) [Abstract]

[Objective] To improve the adhesion of the extruded resin seam which is formed on the opposite side to the injection orifice or orifices when extrusion mould joining cables, and to eliminate insulation damage to the connecting parts.

[Configuration] Two pieces of conductive cable which are to be joined are joined, said joining part is entirely covered by a two-piece metal mould 4 and a reinforcing insulator layer is formed by extruding resin, composed of polyethylene which is not cross-linked, into the interior of the metal mould 4 through injection holes 9′ provided at three places or more in the longitudinal direction of the cable. Because resin is injected from a plurality of resin injection holes 9′, the surface temperature of the lumps of resin is such that they flow together in a state which is maintained at a high temperature and the adhesiveness of the seam is increased. In addition the same effect can be obtained by forming resin injection holes for extrusion in the metal mould 4 in the longitudinal direction of the metal mould 4 from one end to the other end without interruption and by injecting resin into the metal mould 4 to form a thin plate shape.

(Figure caption)

First exemplary embodiment of the present invention

[Scope of patent claims]

[Claim 1] Extrusion mould joining method for cross-linked polyethylene insulated cables composed of a first process in which, when cross-linked polyethylene insulated cables are joined at the laying location, and, on stripping the ends of the two pieces of cable which are to be joined and joining the exposed conductors, an internal electrically conductive layer is formed,

a second process in which the entirety of said joining part is covered by a two-piece metal mould (4), a reinforcing insulating layer is formed by extruding resin composed of polyethylene which is not yet cross-linked into the metal mould (4) and, after the mould (4) has been removed, the surface of the reinforcing insulating layer which has been formed is machined, and

a third process in which, after an external electrically semiconductive layer has been formed on said reinforcing insulating layer, the layers are cross-linked and fused by applying a high temperature, characterized in that the reinforcing insulating layer is formed by providing resin injection holes (9′) for extrusion in the metal mould (4) at three places or more in the longitudinal direction of the cable and injecting resin into the interior of the metal mould (4) through the resin injection holes (9′) which have been provided at three places or more.

[Claim 2] Extrusion mould joining method for cross-linked polyethylene insulated cables composed of a first process in which, when cross-linked polyethylene insulator cables are joined at the laying location, and, on stripping the ends of the two pieces of cable which are to be joined and joining the exposed conductors, an internal electrically conductive layer is formed, and

a second process in which the entirety of said joining part is covered by a two-piece metal mould (4), a reinforcing insulating layer is formed by extruding

resin composed of polyethylene which is not yet cross-linked into the metal mould (4) and, after the mould (4) has been removed, the surface of the reinforcing insulating layer which has been formed is machined,

a third process in which, after an external electrically semiconductive layer has been formed on said reinforcing insulating layer, the layers are cross-linked and fused by applying a high temperature, characterized in that the resin injection holes (9'') for extrusion are formed in the metal mould (4) in the longitudinal direction of the mould from one end to the other end without interruption, and

a reinforcing insulating layer is formed by injecting resin into the metal mould (4) to form a thin plate shape, through said resin injection holes (9'').

[Claim 3] Extrusion mould joining method for cross-linked polyethylene insulated cables according to Claim 2, characterized in that there is a honeycomb structure in which the cross-sections of the resin injection holes (9'') for extrusion in the metal mould (4) are divided up by a plurality of internal walls.

[Detailed description of the invention]

[0001]

[Industrial field of the invention] The present invention relates to improving the methods for joining cables, in particular the present invention relates to improving methods for extrusion mould joining cross-linked polyethylene insulated cables.

[0002]

[Prior art] Thanks to their excellent insulating properties and ease of handling, cross-linked polyethylene insulated cables have been quickly adopted for conversion of lines to high voltage, and 275 kV long-distance lines are being continuously constructed with them. In long-distance lines joining parts are indispensable, and the joining parts used on 275 kV

class cables are extrusion mould-type joining parts in which, after a two-piece metal mould has been placed over the stripped cable insulator elements, insulating resin has been extruded into said mould from a small extrusion device and moulded to a specific shape, an external electrically conductive layer is formed and cross-linked integrally with said extruded insulating layer by applying heat and pressure.

[0003] Figure 3 shows an extrusion mould joining method according to the prior art, and in the same figure 1, 1′ are cables, 2 is a conductor joining tube, 3 is an internal electrically conductive layer, 4 is a two-piece metal mould, 5 is a small extrusion device, 6 is an insulating resin, 7 is a storage tank, 8 is a screw and 9 is a resin injection hole. In Figure 3, when cables 1, 1′ are joined, the cables 1, 1′ which are stripped to prescribed dimensions are compression-joined to one another using the conductor joining tube 2, and an internal electrically conductive layer 3 is formed over the conductor joining tube 2 by means of semiconductive tape and a semiconductive shrink tube.

[0004] Then, the two parts of the metal mould 4 are placed over the latter and insulating resin 6 is extruded into it by means of a small extrusion device 5. After the extruded insulating resin 6 has hardened in the mould, it is machine processed into a prescribed shape of a reinforcing insulating element and after this has been covered with a semiconductive heat shrink tube, it is moulded with the application of heat under a pressurized gas in a pressure vessel.

[0005]

[Problem to be solved by the invention] In the joining method shown in Figure 3, the extrusion process is an extremely complicated phenomenon. In the extrusion process, the resin is usually taken to the cable laying place in pellet form, placed in a storage tank 7

attached to the front of the small extrusion device 5, and as melting is brought about by the application of heat, gradually fed into the metal mould 4 by means of the screw 8 inside the small extrusion device 5.

[0006] There are various types of metal mould 4 with different resin injecting positions, such as at the top, at the side and at the ends etc. However, in all cases, without fail a resin joint (referred to below as a seam) is produced in the internal space of the metal mould 4. Figure 4 shows how the resin flows inside the metal mould 4, and if, for example, as shown in the figure, resin 6 is injected from the central side part of the metal mould, resin which passes over the cable 1 in the interior of the mould 4 and resin which creeps over the lower part of the interior of the metal mould 4 flow together at the side opposite the injection hole 9 and a seam is formed at that part, as shown in figure 4.

[0007] A more detailed explanation will now be given of the flow of resin in the interior of the metal mould 4. The resin which is extruded into the metal mould 4 from the central side part of the metal mould firstly forms a ring containing a seam at the circumference of the cable 1 in centre part, and said ring expands towards the end of the metal mould 4 like a swelling balloon. In other words, the seam which has expanded in the longitudinal direction of the cable 1 at the time when the resin has finally been loaded is formed by the two flows of resin which are extruded in the very first period of the extrusion process, and because of the temperature distribution (in particular near to the internal electrically conductive layer 3), cooling takes place extremely quickly.

[0008] The abovementioned discontinuous surface of the resin at the time of extrusion has an adverse effect electrically. In order to prevent this, it is necessary

to control the temperature of the extrusion resin in a fairly critical way and to proceed in such a way that the surface temperature of the resin extruded into the metal mould 4 does not drop below the prescribed value. However, there has been the problem that the surface of the resin extruded in the first period of the extrusion process varies as a result of seasonal variation in the outside temperature and in the volume of the metal mould accompanying variation in the volume of the cable, and uniform control is difficult.

[0009] The present invention has been devised with the abovementioned deficiencies of the prior art in mind, and its objective is to provide an extrusion mould joining method for cross-linked polyethylene insulated cables whereby, at the time when the cables are extrusion mould joined, the adhesion of the seam formed on the side opposite to the injection orifice or orifices for the extrusion resin can be increased, and, by improving the state of the internal electrically semiconductive layer corresponding to the latter, insulation damage to the joining part as a result of projections of the seam and of the electrically semiconductive layer on the inside of the seam can be eliminated.

[0010]

[Measures for resolving the problem] In order to resolve the abovementioned problem, the present invention according to Claim 1 is an extrusion mould joining method comprising processes in which, when cross-linked polyethylene insulated cables are joined at the laying location, on stripping the ends of two pieces of cable which are to be joined and joining the exposed conductors, an internal electrically conductive layer is formed, the entirety of said joining part is covered by a two-piece metal mould 4, a reinforcing insulating layer is formed by extruding resin composed of polyethylene which has not yet been cross-linked

into the interior of the metal mould 4, and, after the metal mould 4 has been removed, the surface of the reinforcing insulating layer which has been formed is machined, and after an external electrically semiconductive layer has been formed on said reinforcing insulating layer, the layers are cross-linked and fused by applying a high temperature, in which method the reinforcing insulating layer is formed by providing resin injection holes 9′ in the extrusion metal mould 4 at three places or more in the longitudinal direction of the cables, and injecting resin into the interior of the metal mould 4 through the resin injection holes 9′ which have been provided at three places or more.

[0011] In addition, the invention according to Claim 2 is an extrusion mould joining method according to Claim 1, in which resin injection holes 9′′ are formed in the injection metal mould 4 longitudinal direction of the metal mould 4 from one end to the other end without interruption and a reinforcing insulating layer is formed by injecting resin into the metal mould 4 to form a thin plate shape, through said resin injection holes 9′′. The present invention according to Claim 3 is devised such that, in the present invention according to Claim 2, there is a honeycomb structure in which the cross-sections of the resin injection holes 9′′ in the extrusion metal mould 4 are divided up by a plurality of internal walls.

[0012]

[Action] In the present invention according to Claim 1, when resin is injected into the metal mould 4 the resin is injected through a plurality of resin injection holes 9′ which are positioned with a prescribed pitch extending along the longitudinal direction of the metal mould 4. The resin which is extruded into the metal mould 4 collides with the internal electrically semiconductive layer which has been formed beforehand

on the cable joining part and it absorbs heat. After this, the resin is split into a flow which creeps along the inside of the metal mould 4 and a flow which passes over the cable, and said flows flow together on the opposite side of the cable and form a seam.

[0013] At that time, because the resin is injected through the plurality of resin injection holes 9′, in the initial period of extrusion a plurality of resin lumps containing seams are formed not only in the centre part but also along the longitudinal direction, with a prescribed pitch, and after this, the resin lumps swell to such an extent that they fill in the respective intervals between them. For this reason, the surface temperature of the resin lumps is such that they flow together in a state which is maintained at a high temperature, and the adhesiveness of the seam is increased.

[0014] In addition, by configuring the cross-sections of the resin injection holes 9′′ such that they have width corresponding to the distance from one end of the metal mould 4 to the other in the longitudinal direction and by extruding the injected resin into the metal mould 4 in such a way that it rolls in low relief, as in the present invention according to claim 2, the surface temperature of the lumps of resin can, in the same way as in the present invention according to Claim 1, be such that they flow together in a state which is maintained at a high temperature, and the adhesiveness of the seam can be improved.

[0015] Furthermore, as in the present invention according to Claim 3, by forming a honeycomb structure in which the cross-sections of the resin injection holes 9′′ in the present invention according to Claim 2 are divided up by means of a plurality of internal walls, the flow of resin injected into the metal mould 4 can be made the same as in the case in which a

plurality of injection holes are provided.

[0016]

[Exemplary embodiments] Exemplary embodiments of the present invention will be explained below with reference to the figures. Figure 1 is a figure explaining a first exemplary embodiment of the present invention, and in said figure the symbols used correspond to those on the example of the prior art shown in Figure 3. In said figures, 1, 1′ are cables, 2 is a conductor joining tube, 3 is an internal electrically conductive layer, 4 is a two-piece metal mould, 5 is a small extrusion device, 6 is insulating resin, 7 is a storage tank, 8 is a screw and 9′ is a resin injection hole, and in the present exemplary embodiment a plurality of resin injection holes 9′ are provided extending along the longitudinal direction of the metal mould 4, with a prescribed pitch. It is to be noted that it is preferable to provide resin injection holes at at least three places.

[0017] When the cables 1, 1′ in Figure 1 are joined, in the same way as explained in the example of the prior art the cables 1, 1′ which have been stripped to a prescribed dimension are compression-joined to one another using a conductor joining tube 2, and an internal electrically conductive layer 3 is formed on the conductor joining tube 2 by means of an electrically semiconductive tape and an electrically semiconductive shrink tube. Then, a two-piece metal mould 4 is placed over this and insulating resin 6 is extruded into it from a small extrusion device 5.

[0018] The insulating resin 6 is melted in the small extrusion device 5 by applying heat to between 130°C and 140°C (a temperature low enough not to initiate decomposition of the cross-linking agent) and is injected into the metal mould. When the insulating resin 6 is injected into the metal mould 4, the

insulating resin 6 is injected through a plurality of injection holes 9′ which are positioned extending along the longitudinal direction of the metal mould 4, with a prescribed pitch. The resin which is extruded into the metal mould 4 collides, as shown in the abovementioned Figure 4, with the internal electrically semiconductive layer 3 which has been formed beforehand on the cable joining part. The metal mould 4 is preheated and, concomitantly with this, the temperature of the internal electrically semiconductive layer 3 is maintained at between 80°C and 100°C but because this is relatively low in comparison with the temperature of the resin 6, the resin 6 absorbs heat when there is a collision with the internal electrically conductive layer.

[0019] After this, the resin splits into a flow which creeps along the inside of the metal mould 4 and a flow which passes over the cable and said flows flow together on the opposite side of the cable and form a seam. This process is the same as in the case of the prior art but, in the case of the prior art, as the injection holes 9 were only positioned in the centre part, resin lumps containing seams were formed in the centre part and afterwards swelled towards the ends. By the time the resin arrived at the ends, the surface of the resin had cooled to a great extent and it was easy for the problem of discontinuity of the seam to arise.

[0020] In contrast to this, in the present exemplary embodiment a plurality of the resin lumps which contain seams in the first period of extrusion are formed not only in the centre but also along the longitudinal direction, with a prescribed pitch. Thus the resin lumps then merely swell to the extent that they fill the respective intervals between the lumps. In other words, the surface temperature of the resin lumps is such that they flow together in a state in which a higher temperature is maintained than in the prior art.

In this way, the adhesiveness of the seam is increased and this also becomes an advantage in the cross-linking process.

[0021] Next, an explanation will be given of a specific exemplary embodiment in which an extrusion mould-type joining part is assembled by means of the abovementioned method and using 275 kV and 2000 mm^2 cross-linked polyethylene insulated cables.

<u>Exemplary embodiment 1</u>

First, the cables are cut to prescribed dimensions, the conductors are pulled out, and after the ends have been pencilling-processed into a spindle shape, the external electrically conductive layer of the cables is stripped to the prescribed dimensions using a glass cutter and both ends of the cables are compression-joined using a sleeve. In addition, before the compression joining, the necessary products are assembled and an external electrically semiconductive layer tube is passed over the cable core in advance.

[0022] Next, after an internal electrically semiconductive layer has been formed on the joining part by wrapping semiconductive tape over the conductor joining part and carrying out thermal moulding, the joining part is placed in a two-piece metal mould. In one side face of the metal mould, resin injection holes are provided at five places at equal intervals extending from one end of the metal mould to the other, and said holes are connected to a small extrusion device using a 5-line tube and insulating resin is compression-injected from the small extrusion device.

[0023] The resin is split into two pipeways as it is injected into the metal mould and the temperature of the surface of the resin does not drop very much, and the resin fills up the metal mould and forms a reinforcing insulating layer. After cooling to a

predefined temperature, the metal mould is removed, and processing as follows is carried out in a simple clean room. After the extruded insulating elements have been machined to a specific shape using electric tools and a glass cutter, an external electrically conductive layer shrink tube which was passed through the cable beforehand is slid over the joining part and adhered to a certain degree to the reinforcing insulating element by heat shrink fitting by applying hot air by means of a drier or the like, and the shape is adjusted.

[0024] After this, the above is placed in a pressure vessel after providing a cross-linking gas barrier layer and heater and cross-linking is performed by applying heat under a pressurized inert gas, and the device is completed. Electrical testing has been carried out on the extrusion mould joint formed in the way mentioned above and comparisons have been made with an extrusion mould joint formed according to the prior art. Damage values for the specimens (sample number n = 5) formed in accordance with the abovementioned exemplary embodiment 1 were distributed within a stable range stabilized around 1000kV, and among these there was not one in which discontinuities of the seam caused damage.

[0025] In contrast, among the specimens (sample number n = 20) which were formed by injecting into the metal mould from one place in accordance with the prior art, four instances of discontinuities of the seam causing low damage values were found. Figure 2 explains the second exemplary embodiment of the present invention. The same symbols are used for items which are the same as those in Figure 1, and the resin injection holes 9'' in the present exemplary embodiment are formed into a horn shape.

[0026] In the present exemplary embodiment, there is one resin injection hole 9'' but as its cross-section

has a width corresponding to the longitudinal distance from one end of the metal mould 4 to the other and the injected resin is extruded into the metal mould so that it rolls in low relief, the resin lumps which are the same as in the case explained for the first exemplary embodiment are formed not only the centre part but also along the longitudinal direction, and the surface temperature of the resin lumps is such that they flow together in a state which is maintained at a high temperature, and the adhesiveness of the seam is increased.

[0027] In other words, in this exemplary embodiment, the injection holes of the first exemplary embodiment can be thought as having become innumerable. It is to be noted that the resin injection holes 9'' can be given a honeycomb structure by dividing up the cross-sections by means of a plurality of internal walls, and by structuring in this way the flow of resin which is injected into the metal mould can be made the same as a case in which a plurality of injection holes, shown in the first exemplary embodiment, is provided.

[0028] Now, an explanation will be given of a specific exemplary embodiment in which an extrusion mould-type joining part is assembled by means of the abovementioned method, using cables which are the same as in the first exemplary embodiment.

<u>Exemplary embodiment 2</u>

The extrusion metal tool injection holes run from end to end and have an elongated rectangular cross-section with a short side of 10 mm, and the small extrusion device and metal mould are connected by a horn-shaped joining tube.

[0029] The insulating resin is extruded into the metal mould in a state in which it is rolled from said horn-shaped joining tube and a reinforcing insulating layer

is formed. In this exemplary embodiment, it has been possible to form the reinforcing insulating layer in a state in which the drop in the surface temperature of the resin is even less than in exemplary embodiment 1. In the same way as in the exemplary embodiment 1, when a comparison was made between an extrusion-type moulded joint formed in accordance with the present exemplary embodiment and an extrusion-type moulded joint formed in accordance with the prior art, the damage values of specimens (sample number n = 3) formed in accordance with the prior art were found to be the same as the values of exemplary embodiment 1, and, in the same way as with exemplary embodiment 1, there was not one case in which seam discontinuities caused damage.

[0030]

[Effects of the present invention] As is apparent from the explanation above, with the present invention it is possible to reduce the drop of the surface temperature of the resin which flows into the metal mould and to improve the state of the seam formed on the opposite side from the injection orifice or orifices in the reinforcing insulating element, and to improve the condition of the internal electrically semiconductive layer which corresponds to said seam.

[0031] For this reason, it becomes possible to completely eliminate insulator damage to the joining part of the cable due to the seam and a contribution can be made to producing a highly reliable joining parts.

[Brief explanation of the figures]

Figure 1 shows a first exemplary embodiment of the present invention.

Figure 2 shows a second exemplary embodiment of the present invention.

Figure 3 shows an example of the prior art.

Figure 4 shows how resin flows into the metal mould.

[Key to symbols]

1, 1' : Cables

2 : Conductor joining tube

3 : Internal electrically conductive layer

4 : Two-piece metal mould

5 : Small extrusion device

6 : Insulating resin

7 : Storage tank

8 : Screw

9, 9'' : Resin injection holes

A : [Figure 1]

First exemplary embodiment of the present invention

B : [Figure 2]

Second exemplary embodiment of the present invention

C : [Figure 3]

Example of the prior art

D : [Figure 4]

Diagram showing how resin flows into the metal mould

本発明の第1の実施例

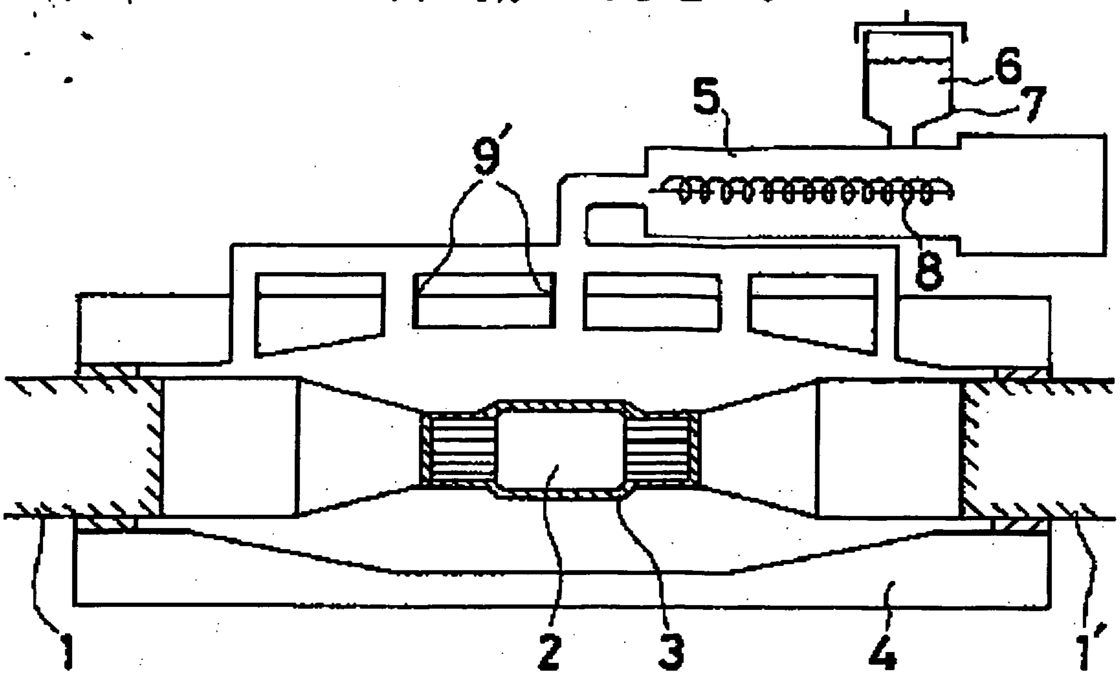

Fig 1

(1/N)

本発明の第2の実施例

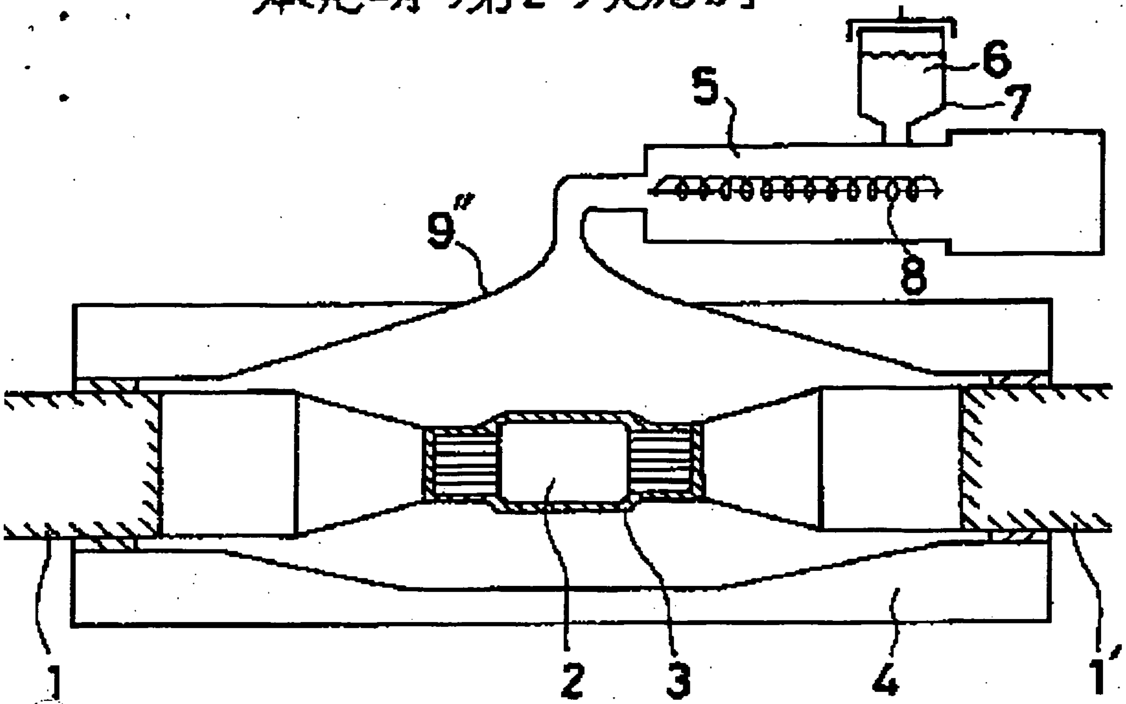

Fig 2

(INV

従 来 例

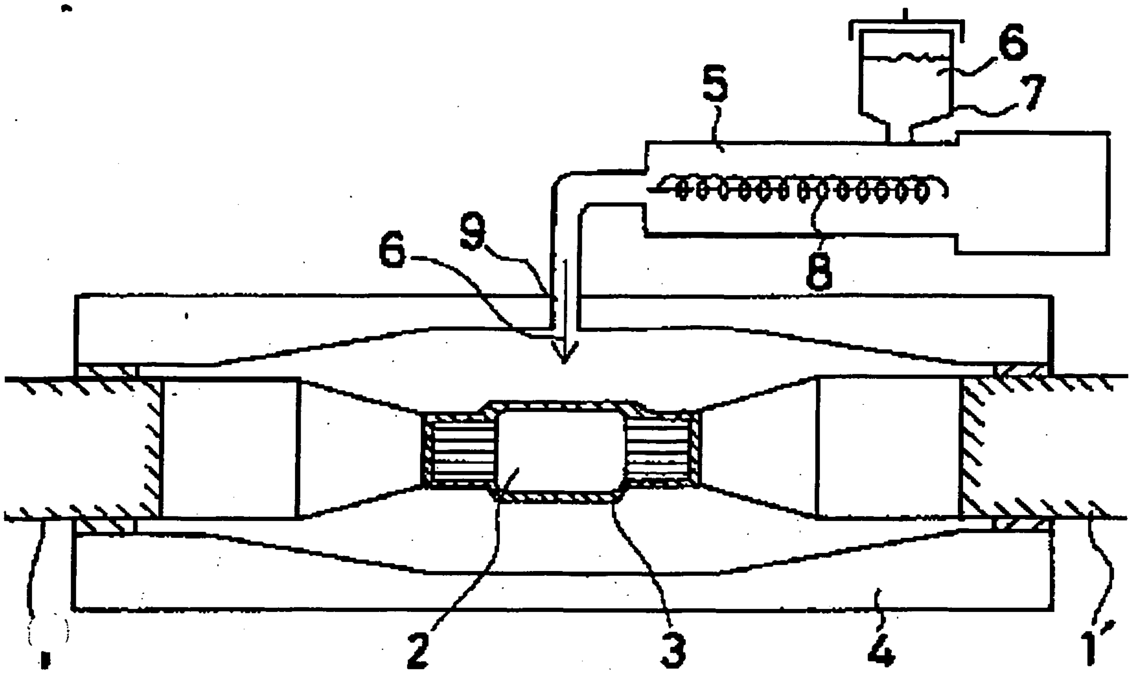

Fig 3
(Prior Art)

金型内を樹脂が流れる様子を示す図

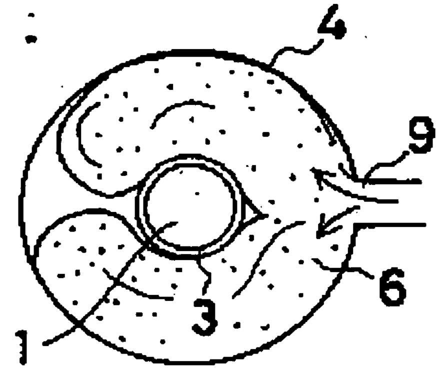

Fig 4

(Prior Art)